

# Claims

- [c1] A method for determining a property of a formation, comprising:  
obtaining radial formation property measurements at different wellbore pressures;  
generating a radial stress profile based on a formation model;  
generating a radial stress function from the radial stress profile; and  
comparing the radial formation property measurements with the radial stress function to determine a formation strength.
- [c2] The method of claim 1, wherein the radial formation property measurements comprise acoustic measurements of one selected from shear slowness, compressional slowness, Stoneley slowness, and a combination thereof.
- [c3] The method of claim 2, wherein the comparing comprises converting the acoustic measurements into a modulus function selected from shear modulus function, Young's modulus function, bulk modulus function, Poisson's ratio function, and Lamé's constant  $\lambda$  func-

tion.

- [c4] The method of claim 1, wherein the different wellbore pressures are obtained by a method selected from changing a pump rate, turning a pump on and off, changing a weight of a drilling fluid, changing a valve setting, allowing ingress of formation fluids, and a combination thereof.
- [c5] The method of claim 1, wherein the formation model is one selected from a linear elastic model, a non-linear elastic model, an elasto-plastic model, a plastic model, and an explicit constitutive model.
- [c6] The method of claim 1, wherein the generating the radial stress profile comprises estimating far-field formation stresses and a wellbore radial stress, the far-field formation stresses comprising a vertical stress, a maximum horizontal stress, and a minimum horizontal stress.
- [c7] The method of claim 6, wherein the vertical stress is estimated from a formation density measurement and the minimum horizontal stress is estimated from a pressure observed when an induced vertical fracture closes.
- [c8] The method of claim 6, wherein the estimating the radial wellbore stress is based on one selected from a weight of a drilling fluid, a wellbore pressure, an equivalent cir-

culating density, and a combination thereof.

[c9] The method of claim 1, wherein the radial stress function is one selected from a shear stress function or a delta shear stress function.

[c10] The method of claim 9, wherein the delta shear stress function is according to:  $\Delta ss = \frac{1}{2}(\sigma_1 - \sigma_3) - \frac{1}{2}(\sigma_v - \sigma_h)$ , wherein  $\Delta ss$  is the delta shear stress function,  $\sigma_v$  is a far-field vertical stress,  $\sigma_h$  is a minimum horizontal far-field stress,  $\sigma_1$  is a maximum stress at a given distance from a wellbore, and  $\sigma_3$  is a minimum stresses at the given distance from the wellbore.

[c11] The method of claim 1, wherein the formation strength is one selected from a formation yield strength, a formation failure strength, and a combination thereof.

[c12] The method of claim 1, wherein the comparing uses a comparison plot of shear slowness versus a delta shear stress function.

[c13] A method for determining a property of a formation, comprising:  
deriving formation parameters from a formation radial profiling;  
obtaining formation log data that comprise formation density data;

estimating formation stresses from the formation log data; and  
deriving a radial stress profile based on a formation model, the derived formation parameters, and the estimated formation stresses.

- [c14] The method of claim 13, wherein the formation radial profiling uses acoustic measurements acquired with a sonic tool equipped with a dipole source.
- [c15] The method of claim 14, wherein the acoustic measurements comprise shear slowness measurements as a function of a distance away from a wellbore.
- [c16] The method of claim 13, wherein the formation parameters comprise ones selected from a formation strength, a location of formation yield, a location of mode transition, and combinations thereof.
- [c17] The method of claim 13, wherein the estimating the formation stresses comprises estimating a far-field vertical stress from the formation density data, estimating a far-field minimum horizontal stress from a pressure observed when an induced vertical fracture closes, and estimating a radial wellbore stress based on one selected from a wellbore pressure, a weight of a drilling fluid, an equivalent circulating density, and a combination

thereof.

- [c18] A method for monitoring formation stability, comprising:  
obtaining formation property measurements at at least two different wellbore pressures; and  
deriving a rate of change of the formation property measurements as a function of wellbore pressure to monitor the formation stability.
- [c19] The method of claim 18, wherein the formation property measurements comprise acoustic measurements.
- [c20] The method of claim 19, wherein the acoustic measurements comprise one selected from compressional slowness measurements, shear slowness measurements, and Stoneley slowness measurements.
- [c21] The method of claim 18, wherein the different wellbore pressures are achieved by one selected from changing a pump rate, turning a pump on and off, changing a weight of a drilling fluid, changing a valve setting, allowing ingress of formation fluids, and a combination thereof.
- [c22] A system for determining a property of a formation, comprising:  
a computer system having a memory for storing a program including instructions for:

obtaining radial formation property measurements at different wellbore pressures;  
generating a radial stress profile based on a formation model;  
generating a radial stress function from the radial stress profile; and  
comparing the radial formation property measurements with the radial stress function to determine a formation strength.

- [c23] The system of claim 22, wherein the radial formation property measurements comprise acoustic measurements of one selected from shear slowness, compressional slowness, Stoneley slowness, and a combination thereof.
- [c24] The system of claim 23, wherein the comparing comprises converting the acoustic measurements into a modulus function selected from shear modulus function, Young's modulus function, bulk modulus function, Poisson's ratio function, and Lamé's constant  $\lambda$  function.
- [c25] The system of claim 22, wherein the different wellbore pressures are obtained by a method selected from changing a pump rate, turning a pump on and off, changing a weight of a drilling fluid, and a combination

thereof.

- [c26] The system of claim 22, wherein the formation model is one selected from a linear elastic model, a non-linear elastic model, an elasto-plastic model, a plastic model, and an explicit constitutive model.
- [c27] The system of claim 22, wherein the generating the radial stress profile comprises estimating far-field formation stresses and a wellbore radial stress, the far-field formation stresses comprising a vertical stress, a maximum horizontal stress, and a minimum horizontal stress.
- [c28] The system of claim 27, wherein the vertical stress is estimated from formation density measurement, the minimum horizontal stress is estimated from a pressure observed when an induced vertical fracture closes, and the radial wellbore stress is estimated from one selected from a weight of a drilling fluid, a wellbore pressure, an equivalent circulating density, and a combination thereof.
- [c29] The system of claim 22, wherein the radial stress function is one selected from a shear stress function and a delta shear stress function.
- [c30] The system of claim 29, wherein the delta shear stress

function is according to:  $\Delta ss = \frac{1}{2}(\sigma_1 - \sigma_3) - \frac{1}{2}(\sigma_v - \sigma_h)$ , wherein  $\Delta ss$  is the delta shear stress function,  $\sigma_v$  is a far-field vertical stress,  $\sigma_h$  is a minimum horizontal far-field stress,  $\sigma_1$  is a maximum stress at a given distance from a wellbore, and  $\sigma_3$  is a minimum stresses at the given distance from the wellbore.

[c31] The system of claim 22, wherein the formation strength is one selected from a formation yield strength, a formation failure strength, and a combination thereof.

[c32] A system for determining a property of a formation, comprising:  
a computer system having a memory for storing a program including instructions for:  
deriving formation parameters from a formation radial profiling;  
obtaining formation log data that comprise formation density data;  
estimating formation stresses from the formation log data; and  
deriving a radial stress profile based on a formation model, the derived formation parameters, and the estimated formation stresses.

[c33] The system of claim 32, wherein the formation radial profiling uses acoustic measurements acquired with a

sonic tool equipped with a dipole source.

- [c34] The system of claim 33, wherein the acoustic measurements comprise shear slowness measurements as a function of a distance away from a wellbore.
- [c35] The system of claim 32, wherein the formation parameters comprise one selected from a formation strength, a location of formation yield, a location of mode transition, and a combination thereof.
- [c36] The system of claim 32, wherein the estimating the formation stresses comprises estimating a far-field vertical stress from the formation density data, estimating a far-field minimum horizontal stress from a pressure required to fracture the formation, and estimating a radial wellbore stress based on one selected from a wellbore pressure, a weight of a drilling fluid, an equivalent circulating density, and a combination thereof.
- [c37] A method for assessing a formation property, comprising:
  - obtaining a series of formation property measurements at different wellbore pressures; and
  - analyzing a rate of change of the series of formation property measurements as a function of wellbore pressures to derive the formation property.

[c38] The method of claim 37, wherein the formation property measurements comprise one selected from acoustic measurements, resistivity measurements, spontaneous potential measurements, and a combination thereof.

[c39] The method of claim 37, wherein the different wellbore pressures are achieved by one selected from changing pump rates, turning a pump on and off, changing a weight of a drilling fluid, changing a valve setting, allowing ingress of formation fluids, and a combination thereof.